WHAT IS CLAIMED IS:

1. In a digital communication system, a method for communicating comprising the steps of:

transmitting signals from one or more transmitter antenna elements;

receiving said signals from via a plurality of receiver antenna elements;

wherein separation of radiation patterns among either said transmitter antenna elements or said receiver antenna elements is insufficient to establish completely isolated spatial directions for communication; and wherein

at least one of said transmitting and receiving steps comprises processing said signals to increase isolation between spatial directions employed for communication at a common frequency.

2. The method of claim 1 wherein a channel coupling said plurality of transmitter antenna elements and receiver antenna elements at said common frequency is characterized by a spatial channel matrix having a rank greater than one.

3. In a digital communication system, a method for communicating comprising the steps of:

transmitting signals from one or more transmitter antenna elements;

receiving said signals via a plurality of receiver antenna elements;

wherein separation of radiation patterns among either said transmitter antenna elements or said receiver antenna elements is insufficient to establish completely isolated spatial directions for communication; and wherein

at least one of said transmitting and receiving steps comprises processing said signals to increase isolation between subchannels, each subchannel associated with a spatial direction and a bin of a substantially orthogonalizing procedure.

4. The method of claim 3 wherein said substantially orthogonalizing procedure belongs to a group including: an inverse Fast Fourier Transform, a Fast Fourier Transform, a Hilbert transform, a wavelet transform, and processing through a set of bandpass filter/frequency upconverter pairs operating at spaced apart frequencies..

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5. In a digital communication system, a method for preparing a sequence of symbols for transmission via a plurality of inputs of a channel:

a) inputting said symbols of said sequence into a plurality of inputs corresponding to a plurality of subchannels of said channel, each subchannel corresponding to an input bin of a transmitter substantially orthogonalizing procedure and a spatial direction;

b) for each input bin, spatially processing symbols inputted to said subchannels corresponding to said input bin, to develop a spatially processed symbol to assign to each combination of channel input and input bin of said transmitter substantially orthogonalizing procedure; and

c) applying, independently for each said channel input, said transmitter substantially orthogonalizing procedure to said spatially processed symbols assigned to each said channel input.

6. The method of claim 5 wherein said b) step has the effect of making spatial directions of said subchannels into a set of orthogonal spatial dimensions.

7. The method of claim 5 wherein said transmitter substantially orthogonalizing procedure belongs to one of a group consisting of an inverse Fast Fourier Transform, a Fast Fourier Transform, a discrete cosine transform, a Hilbert transform, a wavelet transform, and processing through a plurality of bandpass filter/frequency converter pairs centered at spaced apart frequencies.

8. The method of claim 5 further comprising the step of, after said c) step, applying a cyclic prefix processing procedure to a result of said substantially orthogonalizing procedure independently for each channel input.

9. The method of claim 5 wherein said transmitter substantially orthogonalizing procedure is optimized to reduce interference to unintended receivers.

10. The method of claim 5 wherein said b) step comprises, for each particular input bin, multiplying a vector comprising symbols allocated to subchannels corresponding to said input bin by a beneficial weighting matrix, elements of a result vector of said multiplying step corresponding to different channel inputs of said plurality of channel inputs.

11. The method of claim 10 wherein said beneficial weighting matrix comprises an input singular matrix of a matrix containing values representing characteristics of said channel, said coupling said plurality of channel inputs to one or more channel outputs.

12. The method of claim 10 wherein said beneficial weighting matrix is obtained from a matrix containing values representing characteristics of a channel coupling said plurality of channel inputs to one or more channel outputs.

13. The method of claim 10 wherein said beneficial weighting matrix is chosen to reduce interference to unintended receivers.

14. The method of claim 13 wherein said beneficial weighting matrix is chosen based upon characterization of a desired signal subspace.

15. The method of claim 14 wherein said beneficial weighting matrix is chosen further based upon characterization of an undesired signal subspace.

16. The method of claim 15 wherein characterizations of said desired signal subspace and said undesired signal subspace are averaged over at least one of time and frequency.

17. The method of claim 10 wherein said b) step comprises performing said spatial processing step so as to reduce interference radiated to unintended receivers.

18. The method of claim 10 wherein said b) step comprises, for each input bin, allocating symbols to each combination of channel input and input bin so that there

is a one-to-one mapping between spatial direction of a particular subchannel to which a particular symbol has been allocated and channel input to which said particular symbol is allocated.

19. The method of claim 10 further comprising the step of prior to said b) step applying a coding procedure to said symbols.

20. The method of claim 19 wherein said coding procedure is applied independently for each of said subchannels.

21. The method of claim 19 wherein said coding procedure is applied independently for each group of subchannels corresponding to an input bin of said substantially orthogonalizing procedure.

22. The method of claim 19 wherein said coding procedure is applied independently for each group of subchannels corresponding to a particular spatial direction.

23. The method of claim 19 wherein said coding procedure is applied integrally across all of said subchannels.

24. The method of claim 19 wherein said coding procedure belongs to a group consisting of: convolutional coding, Reed-Solomon coding, CRC coding, block coding, trellis coding, turbo coding, and interleaving.

25. The method of claim 19 wherein said coding procedure comprises a trellis coding procedure.

26. The method of claim 25 wherein a code design of said trellis coding procedure is based on one of: improved bit error performance in interference channels, a periodic product distance metric, exhaustive code polynomial search for favorable bit error rate polynomial searches, combined weighting of product distance and Euclidean distance,

product distance of multiple Euclidean distances over short code segments or over a multi-dimensional symbol, and sum of product distances over short code segments.

27. The method of claim 25 wherein a code design of said trellis coding procedure is optimized for performance in a fading matrix channel.

28. The method of claim 19 wherein said coding procedure comprises a one-dimensional trellis coding procedure followed by an interleaving procedure with sequential groups of symbols output by said trellis coding having their internal order maintained by said interleaving procedure.

29. The method of claim 19 wherein said coding procedure comprises a multi-dimensional trellis coding procedure followed by an interleaving procedure with groups of one-dimensional symbols output simultaneously by said multi-dimensional trellis coding procedure having their internal order maintained by said interleaving procedure.

30. The method of claim 10 wherein bit loading and power are allocated to each subchannel.

31. The method of claim 10 further comprising the step of retransmitting symbols by repeating at least one of said a), b), and c) steps upon receipt of a notification that said symbols to be retransmitted have been incorrectly received.

32. The method of claim 10 wherein said channel comprises a wireless channel and said plurality of channel inputs are associated with a corresponding plurality of transmitter antenna elements

33. The method of claim 32 wherein said plurality of transmitter antenna elements are co-located.

34. The method of claim 32 wherein said plurality of transmitters are at disparate locations.

35. A method of processing a sequence of symbols received via a plurality of outputs of a channel, said method comprising the steps of:

a) applying a receiver substantially orthogonalizing procedure to said sequence of symbols, said procedure being applied independently for each of said plurality of channel outputs, each output symbol of said receiver substantially orthogonalizing procedure corresponding to a particular output bin and a particular one of said channel outputs; and

b) for each output bin, spatially processing symbols corresponding to said output bin to develop spatially processed symbols assigned to a plurality of spatial directions, each combination of spatial direction and output bin specifying one of a plurality of subchannels.

36. The method of claim 35 wherein said b) step has the effect of making said plurality of spatial directions into a set of orthogonal spatial dimensions.

37. The method of claim 35 wherein said receiver substantially orthogonalizing procedure belongs to one of a group consisting of an inverse Fast Fourier Transform, a Fast Fourier Transform, a discrete cosine transform, a Hilbert transform, a wavelet transform, and processing through a plurality of bandpass filter/frequency converter pairs centered at spaced apart frequencies.

38. The method of claim 35 further comprising the step of, prior to said a) step, applying a cyclic prefix removal procedure to said sequence of symbols independently for each of said channel outputs.

39. The method of claim 35 wherein said receiver substantially orthogonalizing procedure is optimized to reduce deleterious effects of interference from undesired co-channel transmitters.

40. The method of claim 35 wherein said b) step comprises, for each particular output bin, multiplying a vector comprising symbols of said output bin by a beneficial weighting matrix, elements of a result vector of said multiplying step corresponding to different spatial directions.

41. The method of claim 40 wherein said beneficial weighting matrix comprises an output singular vector of a matrix containing values representing characteristics of said channel, said channel coupling one or more channel inputs to said plurality of channel outputs.

42. The method of claim 40 wherein said beneficial weighting matrix is chosen to minimize deleterious effects of interference from undesired transmitters.

43. The method of claim 42 wherein said beneficial weighting matrix is chosen based upon characterization of a desired signal subspace.

44. The method of claim 43 wherein said beneficial weighting matrix is chosen further based upon characterization of an undesired signal subspace.

45. The method of claim 44 wherein said characterizations of said desired signal subspace and said undesired signal subspace are averaged over at least one of time and frequency.

46. The method of claim 40 wherein said beneficial weighting matrix is obtained from a matrix containing values representing characteristics of said channel, said channel coupling one or more channel inputs and said plurality of channel outputs.

47. The method of claim 46 wherein said beneficial weighting matrix is obtained by an MMSE procedure.

48. The method of claim 35 further comprising the step of after said b) step applying a decoding procedure to said symbols.

49. The method of claim 48 wherein said decoding procedure is applied independently for each of said plurality of subchannels.

50. The method of claim 48 wherein said decoding procedure is applied independently for each group of subchannels corresponding to an output bin of said substantially orthogonalizing procedure.

51. The method of claim 48 wherein said decoding procedure is applied independently for each group of subchannels corresponding to a spatial direction.

52. The method of claim 48 wherein said decoding procedure is applied integrally across all of said plurality of subchannels.

53. The method of claim 48 wherein said decoding procedure belongs to a group consisting of: Reed-Solomon decoding, CRC decoding, block decoding, and de-interleaving.

54. The method of claim 48 wherein said decoding procedure comprises a code sequence detection procedure to decode a trellis code, or convolutional code.

55. The method of claim 54 wherein said code sequence detection procedure employs a metric belonging to a group consisting of: Euclidean metric, weighted Euclidean metric, and Hamming metric.

56. The method of claim 48 wherein said decoding procedure reduces deleterious effects of interference from undesired transmitters.

57. The method of claim 35 further comprising the step of:

sending a retransmission request when received symbols are determined to include errors.

58. The method of claim 35 wherein said channel comprises a wireless channel and said plurality of channel outputs are coupled to a plurality of corresponding receiver antenna elements.

59. The method of claim 35 wherein said plurality of receiver antenna elements are co-located.

60. The method of claim 35 wherein said plurality of receiver antenna elements are at disparate locations.

61. In a digital communication system, a method for preparing a sequence of symbols for transmission via a plurality of inputs to a channel, said method comprising the steps of:

selecting a weighting vector for optimal transmission;

applying a transmitter substantially orthogonalizing procedure to said sequence of symbols to develop a time domain symbol sequence; and

multiplying at least one symbol of said time domain symbol sequence by said weighting vector to develop a result vector, elements of said result vector corresponding to symbols to be transmitted via individual ones of said plurality of channel inputs.

62. The method of claim 61 wherein said weighting vector comprises an element indicating delay to be applied for a particular one of said plurality of channel inputs.

63. The method of claim 61 wherein said weighting vector is optimized to reduce interference to unintended receivers.

64. The method of claim 61 wherein said weighting vector is chosen based upon characterization of a desired signal subspace.

65. The method of claim 64 wherein said weighting vector is chosen further based upon characterization of an undesired signal subspace.

66. The method of claim 65 wherein said characterizations of said desired signal subspace and said undesired signal subspace are averaged over at least one of time and frequency.

67. The method of claim 61 wherein said channel comprises a wireless channel and said plurality of channel inputs are associated with a plurality of transmitter antenna elements.

68. In a digital communication system, a method for processing a plurality of symbols received via a plurality of outputs of a channel, said method comprising the steps of:

selecting a weighting vector for optimal reception;

multiplying an input vector whose elements correspond to symbols received substantially simultaneously via a selected one of said plurality of channel outputs by said weighting vector to obtain a time domain symbol corresponding to a particular input bin of a receiver substantially orthogonalizing procedure;

repeating said multiplying step for successive received symbols to obtain time domain symbols corresponding to successive input bins of said receiver substantially orthogonalizing procedure; and

applying said receiver substantially orthogonalizing procedure to said obtained time domain symbols.

69. The method of claim 68 wherein said weighting vector comprises an element indicating delay to be applied for a particular one of said plurality of channel outputs.

70. The method of claim 68 wherein said weighting vector is optimized to reduce deleterious effects of interference from unintended transmitters.

71. The method of claim 68 wherein said weighting vector is chosen based upon characterization of a desired signal subspace.

72. The method of claim 71 wherein said weighting vector is chosen further based upon characterization of an undesired signal subspace.

73. The method of claim 72 wherein said characerizations of said desired signal subspace and said undesired signal subspace are averaged over at least one of frequency and time.

74. The method of claim 71 wherein said channel comprises a wireless channel and said plurality of channel outputs are associated with a plurality of corresponding receiver antenna elements.

75. In a digital communication system, a method of preparing symbols for transmission via a plurality of inputs of a channel, said method comprising the steps of:

directing symbols to input bins of a transmitter substantially orthogonalizing procedure so that each input bin has an allocated symbol;

for each particular input bin, spatially processing said symbol allocated to said particular input bin to develop a spatially processed symbol vector, each element of said spatially processed symbol vector being assigned to one of said channel inputs;

applying said transmitter substantially orthogonalizing procedure for a particular channel input, inputs to said substantially orthogonalizing procedure being for each input bin, a symbol of said processed symbol vector for said input bin corresponding to said particular channel input; and

repeating said applying step for each of said plurality of channel inputs.

76. The method of claim 75 further comprising the step of:

applying a cyclic prefix processing procedure to outputs of said substantially orthogonalizing procedure independently for each particular channel input.

77. The method of claim 75 wherein said transmitter substantially orthogonalizing procedure is optimized to reduce interference to unintended receivers.

78. The method of claim 75 wherein said processing step comprises:

multiplying said symbol allocated to said particular input bin by a beneficial weighting vector to obtain said spatially processed symbol vector.

79. The method of claim 78 wherein said beneficial weighting vector is an input singular vector of a matrix storing values indicative of said channel, said channel coupling said plurality of channel inputs and one or more channel outputs.

80. The method of claim 78 wherein said beneficial weighting vector is chosen to select a beneficial spatial direction for transmission.

81. The method of claim 80 wherein said beneficial weighting vector is chosen to reduce interference to unintended receivers.

82. The method of claim 81 wherein said beneficial weighting vector is chosen based upon characterization of a desired signal subspace

83. The method of claim 82 wherein said beneficial weighting vector is chosen further based upon characterization of an undesired signal subspace.

84. The method of claim 83 wherein said characterizations of said desired signal subspace and said undesired signal subspace are averaged over at least one of time and frequency.

85. The method of claim 75 wherein said channel comprises a wireless channel and said plurality of channel inputs are associated with a corresponding plurality of transmitter antenna elements.

86. In a digital communication system, a method for processing symbols received by a plurality of outputs of a channel comprising the step of:

applying a receiver substantially orthogonalizing procedure to symbols received via a particular one of said channel outputs;

repeating said applying step for each of said channel outputs to develop a result vector for each of a plurality of output bins of said receiver substantially orthogonalizing procedure, said result vector including a result symbol for each of said channel outputs; and

for each particular output bin of said receiver substantially orthogonalizing procedure, spatially processing said result vector for said particular output bin to develop a spatially processed result symbol for said particular output bin.

87. The method of claim 86 further comprising the step of:

prior to said applying step, applying a cyclic prefix removal procedure to symbols independently for each of said channel outputs.

88. The method of claim 86 wherein said substantially orthogonalizing procedure is optimized to reduce deleterious effects of interference from unintended transmitters.

89. The method of claim 86 wherein said spatially processing step comprises multiplying a beneficial weighting vector by said result vector to obtain said spatially processed result symbol.

90. The method of claim 88 wherein said beneficial weighting vector is an input singular vector of a matrix storing values indicative of characteristics of said channel, said channel coupling one or more chanel inputs and said plurality of channel outputs.

91. The method of claim 88 wherein said beneficial weighting vector is chosen to select a particular spatial direction for reception.

92. The method of claim 91 wherein said beneficial weighting vector is chosen to minimize deleterious effects of interference from unintended transmitters.

93. The method of claim 91 wherein said beneficial weighting vector is chosen based upon characterization of a desired signal subspace.

94. The method of claim 93 wherein said beneficial weighting vector is chosen based upon characterization of an undesired signal subspace.

95. The method of claim 94 wherein said characterizations of said desired signal subspace and said undesired signal subspace are averaged over at least one of time and frequency.

96. The method of claim 86 wherein said channel comprises a wireless channel and said plurality of channel outputs are associated with a corresponding plurality of channel outputs.

97. In a digital communication system including a communication channel having one or more inputs and at least one or more outputs, a method for determining characteristics of said channel based on signals received by said one or more outputs, comprising the steps of:

a) receiving via said one or more channel outputs, at least ν training symbols transmitted via a particular spatial direction of said channel, ν being an extent in symbol periods of a duration of significant terms of an impulse response of a channel; and

b) applying a substantially orthogonalizing procedure to said received at least ν training symbols to obtain a time domain response for said spatial direction; and

c) applying an inverse of said substantially orthogonalizing procedure to a zero-padded version of said time domain response to obtain a frequency response for said particular spatial direction.

98. The method of claim 97 wherein said substantially orthogonalizing procedure comprises an inverse Fast Fourier Transform and said inverse of said substantially orthogonalizing procedure comprises a Fast Fourier Transform.

99. The method of claim 98 wherein said a) step comprises receiving exactly ν training symbols.

100. The method of claim 97 further comprising the step of repeating said a), b), c), and d) steps for a plurality of spatial directions.

101. The method of claim 99 wherein each of said plurality of spatial directions corresponds to transmission through one of said plurality of channel inputs exclusively.

102. The method of claim 98 wherein said ν training symbols belong to a burst of N symbols and said characteristics are determined for said burst.

103. The method of claim 102 further comprising the steps of repeating said a), b), c), and d) steps for successive bursts.

104. The method of claim 103 further comprising the step of after, said b) step, smoothing said time-domain response over successive bursts.

105. The method of claim 104 wherein said smoothing step comprises Kalman filtering.

106. The method of claim 104 wherein said smoothing step comprises Wiener filtering.

107. The method of claim 97 wherein said communication channel comprises known and unknown components, wherein said effects of said known components are removed by deconvolution, and characteristics of said unknown components are determined by said a), b), c), and d) steps, thereby reducing .

108. In a digital communication system including a communication channel having one or more inputs and one or more outputs, a method for determining characteristics of said channel based on signals received via one or more channel outputs, comprising the steps of:

receiving training symbols via said channel outputs; and

computing characteristics of said channel based on said received training symbols and assumptions that an impulse response of said channel is substantially time-limited and that variation of said impulse response over time is continuous.

109. In a digital communication system, a method for communicating over a channel having at least one input and at least one output, and having a plurality of either inputs or outputs, said method comprising the steps of:

dividing said channel into a plurality of subchannels, each subchannel corresponding to a combination of spatial direction and an input bin of a substantially orthogonalizing procedure; and

communicating symbols over one or more of said plurality of subchannels.

110. In a digital communication system, a method for preparing a sequence of symbols for transmission via a plurality of inputs of a channel, comprising the steps of:

a) inputting said symbols of said sequence into a plurality of input corresponding to a plurality of subchannels of said channel, each subchannel corresponding to an input bin of a transmitter substantially orthogonalizing procedure and a channel input; and

b) applying, independently for each said channel input, said transmitter substantially orthogonalizing procedure to said symbols assigned to each said channel input.

111. A method of processing a sequence of symbols received via a plurality of outputs of a channel, said method comprising the steps of:

a) applying a substantially orthogonalizing procedure to said sequence of symbols, said procedure being applied independently for each of said plurality of channel outputs, each output symbol of said substantially orthogonalizing procedure corresponding to a subchannel identified by a combination of a particular output bin and a particular one of said channel outputs; and

b) processing symbols in said subchannels.

112. In a digital communication system, apparatus for communicating comprising:

a transmitter that transmits signals from one or more transmitter antenna elements;

a receiver that receives said signals from via a plurality of receiver antenna elements;

wherein separation of radiation patterns among either said transmitter antenna elements or said receiver antenna elements is insufficient to establish completely isolated spatial directions for communication; and wherein

at least one of said transmitter and said receiver comprises a processor that processes said signals to increase isolation between spatial directions employed for communication at a common frequency.

113. The apparatus of claim 112 wherein a channel coupling said plurality of transmitter antenna elements and receiver antenna elements at said common frequency is characterized by a spatial channel matrix having a rank greater than one.

114. In a digital communication system, apparatus for communicating comprising:

a transmitter transmitting signals from one or more transmitter antenna elements;

a receiver receiving said signals via a plurality of receiver antenna elements;

wherein separation of radiation patterns among either said transmitter antenna elements or said receiver antenna elements is insufficient to establish completely isolated spatial directions for communication; and wherein

at least one of said transmitter and said receiver comprises a processor that processes said signals to increase isolation between subchannels, each subchannel associated with a spatial direction and a bin of a substantially orthogonalizing procedure.

115. The apparatus of claim 114 wherein said substantially orthogonalizing procedure belongs to a group including: an inverse Fast Fourier Transform, a Fast Fourier Transform, a Hilbert transform, a wavelet transform, and processing through a set of bandpass filter/frequency upconverter pairs operating at spaced apart frequencies..

116. In a digital communication system, apparatus for preparing a sequence of symbols for transmission via a plurality of inputs of a channel:

a plurality of parallel subchannel inputs receiving said symbols, said parallel subchannel inputs corresponding to a plurality of subchannels, each subchannel corresponding to an input bin of a transmitter substantially orthogonalizing procedure and a spatial direction;

a spatial processor that, for each input bin, spatially processor symbols received by said subchannel inputs corresponding to said input bin, to develop a spatially processed symbol to assign to each combination of channel input and input bin of said transmitter substantially orthogonalizing procedure; and

a substantially orthogonal procedure processor system that applies, independently for each said channel input, said transmitter substantially orthogonalizing procedure to said spatially processed symbols assigned to each said channel input.

117. The apparatus of claim 116 wherein said spatial processor has the effect of making spatial directions of said subchannels into a set of orthogonal spatial dimensions.

118. The apparatus of claim 116 wherein said transmitter substantially orthogonalizing procedure belongs to one of a group consisting of an inverse Fast Fourier Transform, a Fast Fourier Transform, a discrete cosine transform, a Hilbert transform, a wavelet transform, and processing through a plurality of bandpass filter/frequency converter pairs centered at spaced apart frequencies.

119. The apparatus of claim 116 further comprising: a cyclic prefix processor that applies a cyclic prefix processing procedure to a result of said substantially orthogonalizing procedure independently for each channel input.

120. The apparatus of claim 116 wherein said transmitter substantially orthogonalizing procedure is optimized to reduce interference to unintended receivers.

121. The apparatus of claim 116 wherein said spatial processor comprises, for each particular input bin, a weight multiplier that multiplies a vector comprising symbols allocated to subchannels corresponding to said input bin by a beneficial weighting matrix, elements of a result vector of said weight multiplier corresponding to different channel inputs of said plurality of channel inputs.

122. The apparatus of claim 121 wherein said beneficial weighting matrix comprises an input singular matrix of a matrix containing values representing characteristics of said channel, said channel coupling said plurality of channel inputs to one or more channel outputs.

123. The apparatus of claim 121 wherein said beneficial weighting matrix is obtained from a matrix containing values representing characteristics of a channel coupling said plurality of channel inputs to one or more channel outputs.

124. The apparatus of claim 121 wherein said beneficial weighting matrix is chosen to reduce interference to unintended receivers.

125. The apparatus of claim 124 wherein said beneficial weighting matrix is chosen based upon characterization of a desired signal subspace.

126. The apparatus of claim 125 wherein said beneficial weighting matrix is chosen further based upon characterization of an undesired signal subspace.

127. The apparatus of claim 126 wherein characterizations of said desired signal subspace and said undesired signal subspace are averaged over at least one of time and frequency.

128. The apparatus of claim 116 wherein said spatial processor operates so as to reduce interference radiated to unintended receivers.

129. The apparatus of claim 116 wherein said spatial processor, allocates symbols to each combination of channel input and input bin so that there is a one-to-one mapping between spatial direction of a particular subchannel to which a particular symbol has been allocated and channel input to which said particular symbol is allocated.

130. The apparatus of claim 116 further comprising a coder that applies a coding procedure to said symbols prior to processing by said spatial processor.

131. The apparatus of claim 130 wherein said coding procedure is applied independently for each of said subchannels.

132. The apparatus of claim 130 wherein said coding procedure is applied independently for each group of subchannels corresponding to an input bin of said substantially orthogonalizing procedure.

133. The apparatus of claim 130 wherein said coding procedure is applied independently for each group of subchannels corresponding to a particular spatial direction.

134. The apparatus of claim 130 wherein said coding procedure is applied integrally across all of said subchannels.

135. The apparatus of claim 130 wherein said coding procedure belongs to a group consisting of: convolutional coding, Reed-Solomon coding, CRC coding, block coding, trellis coding, turbo coding, and interleaving.

136. The apparatus of claim 130 wherein said coding procedure comprises a trellis coding procedure.

137. The apparatus of claim 136 wherein a code design of said trellis coding procedure is based on one of: improved bit error performance in interference channels, a periodic product distance metric, exhaustive code polynomial search for favorable bit error rate polynomial searches, combined weighting of product distance and Euclidean distance, product distance of multiple Euclidean distances over short code segments or over a multi-dimensional symbol, and sum of product distances over short code segments.

138. The apparatus of claim 136 wherein a code design of said trellis coding procedure is optimized for performance in a fading matrix channel.

139. The apparatus of claim 130 wherein said coding procedure comprises a one-dimensional trellis coding procedure followed by an interleaving procedure with sequential groups of symbols output by said trellis coding having their internal order maintained by said interleaving procedure.

140. The apparatus of claim 130 wherein said coding procedure comprises a multi-dimensional trellis coding procedure followed by an interleaving procedure with groups of one-dimensional symbols output simultaneously by said multi-dimensional trellis coding procedure having their internal order maintained by said interleaving procedure.

141. The apparatus of claim 130 wherein bit loading and power are allocated to each subchannel.

142. The apparatus of claim 116 further comprising an ARQ system that retransmits symbols via at least one of said spatial processor, and said substantially orthogonalizing procedure processor upon receipt of a notification that said symbols to be retransmitted have been incorrectly received.

143. The apparatus of claim 116 wherein said channel comprises a wireless channel and said plurality of channel inputs are associated with a corresponding plurality of transmitter antenna elements

144. The apparatus of claim 142 wherein said plurality of transmitter antenna elements are co-located.

145. The apparatus of claim 144 wherein said plurality of transmitters are at disparate locations.

146. Apparatus of processing a sequence of symbols received via a plurality of outputs of a channel, said apparatus comprising:

a substantially orthogonalizing procedure processor system that applies a receiver substantially orthogonalizing procedure to said sequence of symbols, said procedure being applied independently for each of said plurality of channel outputs, each output symbol of said substantially orthogonalizing procedure corresponding to a particular output bin and a particular one of said channel outputs; and

a spatial processor that, for each output bin, spatially processes symbols corresponding to said output bin to develop spatially processed symbols assigned to a plurality of spatial directions, each combination of spatial direction and output bin specifying one of a plurality of subchannels.

147. The apparatus of claim 146 wherein said spatial processor operates to make said plurality of spatial directions into a set of orthogonal spatial dimensions.

148. The apparatus of claim 146 wherein said receiver substantially orthogonalizing procedure belongs to one of a group consisting of an inverse Fast Fourier Transform, a Fast Fourier Transform, a discrete cosine transform, a Hilbert transform, a wavelet transform, and processing through a plurality of bandpass filter/frequency converter pairs centered at spaced apart frequencies.

149. The apparatus of claim 146 further comprising: a cyclic prefix processor that applies a cyclic prefix removal procedure to said sequence of symbols independently for each of said channel outputs.

150. The apparatus of claim 146 wherein said receiver substantially orthogonalizing procedure is optimized to reduce deleterious effects of interference from undesired co-channel transmitters.

151. The apparatus of claim 146 wherein said spatial processor comprises, for each particular output bin, a weight multiplier that multiplies a vector comprising symbols of said output bin by a beneficial weighting matrix, elements of a result vector of said multiplier corresponding to different spatial directions.

152. The apparatus of claim 151 wherein said beneficial weighting matrix comprises an output singular vector of a matrix containing values representing characteristics of said channel, said channel coupling one or more channel inputs to said plurality of channel outputs.

153. The apparatus of claim 151 wherein said beneficial weighting matrix is chosen to minimize deleterious effects of interference from undesired transmitters.

154. The apparatus of claim 151 wherein said beneficial weighting matrix is chosen based upon characterization of a desired signal subspace.

155. The apparatus of claim 154 wherein said beneficial weighting matrix is chosen further based upon characterization of an undesired signal subspace.

156. The apparatus of claim 155 wherein said characterizations of said desired signal subspace and said undesired signal subspace are averaged over at least one of time and frequency.

157. The apparatus of claim 151 wherein said beneficial weighting matrix is obtained from a matrix containing values representing characteristics of said channel, said channel coupling one or more channel inputs and said plurality of channel outputs.

158. The apparatus of claim 157 wherein said beneficial weighting matrix is obtained by an MMSE procedure.

159. The apparatus of claim 146 further comprising: a decoder that applies a decoding procedure to said spatially processed symbols.

160. The apparatus of claim 159 wherein said decoding procedure is applied independently for each of said plurality of subchannels.

161. The apparatus of claim 159 wherein said decoding procedure is applied independently for each group of subchannels corresponding to an output bin of said substantially orthogonalizing procedure.

162. The apparatus of claim 159 wherein said decoding procedure is applied independently for each group of subchannels corresponding to a spatial direction.

163. The apparatus of claim 159 wherein said decoding procedure is applied integrally across all of said plurality of subchannels.

164. The apparatus of claim 159 wherein said decoding procedure belongs to a group consisting of: Reed-Solomon decoding, CRC decoding, block decoding, and de-interleaving.

165. The apparatus of claim 159 wherein said decoding procedure comprises a code sequence detection procedure to decode a trellis code, or convolutional code.

166. The apparatus of claim 165 wherein said code sequence detection procedure employs a metric belonging to a group consisting of: Euclidean metric, weighted Euclidean metric, and Hamming metric.

167. The apparatus of claim 159 wherein said decoding procedure reduces deleterious effects of interference from undesired transmitters.

168. The apparatus of claim 146 further comprising:

a system that sends a retransmission request when received symbols are determined to include errors.

169. The apparatus of claim 170 wherein said channel comprises a wireless channel and said plurality of channel outputs are coupled to a plurality of corresponding receiver antenna elements.

171. The apparatus of claim 170 wherein said plurality of receiver antenna elements are co-located.

172. The apparatus of claim 170 wherein said plurality of receiver antenna elements are at disparate locations.

173. In a digital communication system, apparatus for preparing a sequence of symbols for transmission via a plurality of inputs to a channel, said apparatus comprising:

a substantially orthogonal procedure processor that applies a transmitter substantially orthogonalizing procedure to said sequence of symbols to develop a time domain symbol sequence; and

a weight multiplier that multiplies at least one symbol of said time domain symbol sequence by a weighting vector selected for improved communication to develop a result vector, elements of said result vector corresponding to symbols to be transmitted via individual ones of said plurality of channel inputs.

174. The apparatus of claim 173 wherein said weighting vector comprises an element indicating delay to be applied for a particular one of said plurality of channel inputs.

175. The apparatus of claim 174 wherein said weighting vector is optimized to reduce interference to unintended receivers.

176. The apparatus of claim 173 wherein said weighting vector is chosen based upon characterization of a desired signal subspace.

177. The apparatus of claim 176 wherein said weighting vector is chosen further based upon characterization of an undesired signal subspace.

178. The apparatus of claim 177 wherein said characterizations of said desired signal subspace and said undesired signal subspace are averaged over at least one of time and frequency.

179. The apparatus of claim 173 wherein said channel comprises a wireless channel and said plurality of channel inputs are associated with a plurality of transmitter antenna elements.

180.

180. In a digital communication system, apparatus for processing a plurality of symbols received via a plurality of outputs of a channel, said apparatus comprising:

a weight multiplier that performs a multiplication of an input vector whose elements correspond to symbols received substantially simultaneously via a selected one of said plurality of channel outputs by a weighting vector to obtain a time domain symbol corresponding to a particular input bin of a receiver substantially orthogonalizing procedure and that repeats said multiplication for successive received symbols to obtain time domain symbols corresponding to successive input bins of said receiver substantially orthogonalizing procedure; and

a substantial orthogonalizing procedure processor that applies said substantially orthogonalizing procedure processor to said obtained time domain symbols.

181. The apparatus of claim 180 wherein said weighting vector comprises an element indicating delay to be applied for a particular one of said plurality of channel outputs.

182. The apparatus of claim 180 wherein said weighting vector is optimized to reduce deleterious effects of interference from unintended transmitters.

183. The apparatus of claim 180 wherein said weighting vector is chosen based upon characterization of a desired signal subspace.

184. The apparatus of claim 183 wherein said weighting vector is chosen further based upon characterization of an undesired signal subspace.

185. The apparatus of claim 184 wherein said characterizations of said desired signal subspace and said undesired signal subspace are averaged over at least one of frequency and time.

186. The apparatus of claim 180 wherein said channel comprises a wireless channel and said plurality of channel outputs are associated with a plurality of corresponding receiver antenna elements.

187. In a digital communication system, apparatus for preparing symbols for transmission via a plurality of inputs of a channel, said apparatus comprising:

a plurality of symbol inputs, each of said symbol inputs receiving a symbol intended for a particular input bin of a transmitter substantially orthogonalizing procedure so that each of a plurality of input bins of said transmitter substantially orthongonalizing procedure has an allocated symbol;

a spatial processor that, for each particular input bin of said plurality of input bins, spatially processes said symbol allocated to said particular input bin to develop a spatially processed symbol vector, each element of said spatially processed symbol vector being assigned to one of said channel inputs; and

a substantially orthogonalizing procedure processor that applies said substantially orthogonalizing procedure for a particular channel input, inputs to said substantially orthogonalizing procedure being for each input bin, a symbol of said processed symbol vector for said input bin corresponding to said particular channel input, and that applies said sustantially orthogonalizing procedure for each of said plurality of channel inputs.

188. The apparatus of claim 187 further comprising:

a cyclic prefix processor that applies a cyclic prefix processing procedure to outputs of said substantially orthogonalizing procedure independently for each particular channel input.

189. The apparatus of claim 187 wherein said substantially orthogonalizing procedure is optimized to reduce interference to unintended receivers.

190. The apparatus of claim 187 wherein said spatial processor comprises:

a weight multiplier that multiplies said symbol allocated to said particular input bin by a beneficial weighting vector to obtain said spatially processed symbol vector.

191. The apparatus of claim 190 wherein said beneficial weighting vector is an input singular vector of a matrix storing values indicative of characteristics of said channel, said channel coupling said plurality of channel inputs and one or more channel outputs.

192. The apparatus of claim 190 wherein said beneficial weighting vector is chosen to select a beneficial spatial direction for transmission.

193. The apparatus of claim 191 wherein said beneficial weighting vector is chosen to reduce interference to unintended receivers.

194. The apparatus of claim 193 wherein said beneficial weighting vector is chosen based upon characterization of a desired signal subspace

195. The apparatus of claim 194 wherein said beneficial weighting vector is chosen further based upon characterization of an undesired signal subspace.

196. The apparatus of claim 195 wherein said characterizations of said desired signal subspace and said undesired signal subspace are averaged over at least one of time and frequency.

197. The apparatus of claim 187 wherein said channel comprises a wireless channel and said plurality of channel inputs are associated with a corresponding plurality of transmitter antenna elements.

198. In a digital communication system, apparatus for processing symbols received by a plurality of outputs of a channel comprising:

a substantially orthogonalizing procedure processor that applies a receiver substantially orthogonalizing procedure to symbols received via a particular one of said channel outputs and that said applies said receiver substantially orthogonalizing procedure for each of said channel outputs to develop a result vector for each of a plurality of output bins of said substantially orthogonalizing procedure, said result vector including a result symbol for each of said channel outputs; and

a spatial processor that, for each particular output bin of said substantially orthogonalizing procedure, spatially processes said result vector for said particular output bin to develop a spatially processed result symbol for said particular output bin.

199. The apparatus of claim 198 further comprising: a cyclic prefix removal processor that applies a cyclic prefix removal procedure to symbols independently for each of said channel outputs.

200. The apparatus of claim 198 wherein said substantially orthogonalizing procedure is optimized to reduce deleterious effects of interference from unintended transmitters.

201. The apparatus of claim 198 wherein said spatially processor comprises a weight multiplier that multiplies a beneficial weighting vector by said result vector to obtain said spatially processed result symbol.

202. The apparatus of claim 201 wherein said beneficial weighting vector is an input singular vector of a matrix storing values indicative of characteristics of said channel, said channel coupling one or more chanel inputs and said plurality of channel outputs.

203. The apparatus of claim 201 wherein said beneficial weighting vector is chosen to select a particular spatial direction for reception.

204. The apparatus of claim 203 wherein said beneficial weighting vector is chosen to minimize deleterious effects of interference from unintended transmitters.

205. The apparatus of claim 204 wherein said beneficial weighting vector is chosen based upon characterization of a desired signal subspace.

206. The apparatus of claim 205 wherein said beneficial weighting vector is chosen based upon characterization of an undesired signal subspace.

207. The apparatus of claim 206 wherein said characterizations of said desired signal subspace and said undesired signal subspace are averaged over at least one of time and frequency.

208. The apparatus of claim 198 wherein said channel comprises a wireless channel and said plurality of channel outputs are associated with a corresponding plurality of channel outputs.

209. In a digital communication system including a communication channel having one or more inputs and at least one or more outputs apparatus for determining

characteristics of said channel based on signals received by said one or more outputs, comprising:

a receiver system receiving via said one or more channel outputs, at least training symbols transmitted via a particular spatial direction of said channel, being an extent in symbol periods of a duration of significant terms of an impulse response of a channel;

a substantially orthogonalizing procedure processor that applies a substantially orthogonalizing procedure processor to said received at least training symbols to obtain a time domain response for said particular spatial direction; and

an inverse substantially orthogonalizing procedure processor that applies an inverse of said substantially orthogonalizing procedure to a zero-padded version of said time domain response to obtain a frequency response for said particular spatial direction.

210. The apparatus of claim 209 wherein said substantially orthogonalizing procedure comprises an inverse Fast Fourier Transform and said inverse of said substantially orthogonalizing procedure comprises a Fast Fourier Transform.

211. The apparatus of claim 209 wherein said receiver system receives exactly training symbols.

212. The apparatus of claim 209 wherein said receiver system, said substantially orthogonalizing procedure processor and said inverse substantially orthogonalizing procedure process operate repeatedly for a plurality of spatial directions.

213. The apparatus of claim 209 wherein each of said plurality of spatial directions corresponds to transmission through one of said plurality of channel inputs exclusively.

214. The apparatus of claim 209 wherein said training symbols belong to a burst of N symbols and said characteristics are determined for said burst.

215. The apparatus of claim 214 said receiver system, said substantially orthogonalizing procedure processor and said inverse substantially orthogonalizing procedure process operate repeatedly for a plurality of bursts.

216. The apparatus of claim 215 further comprising:

means for smoothing said time-domain response over successive bursts.

217. The apparatus of claim 216 wherein said smoothing means comprises:

means for Kalman filtering said time-domain response over successive bursts.

218. The apparatus of claim 217 wherein said smoothing means comprises means for Wiener filtering said time-domain response over successive bursts.

219. The apparatus of claim 209 wherein said communication channel comprises known and unknown components, wherein said effects of said known components are removed by deconvolution, and characteristics of said unknown components are determined by said a), b), c), and d) steps, thereby reducing .

220. In a digital communication system including a communication channel having one or more inputs and one or more outputs, apparatus for determining characteristics of said channel based on signals received via one or more channel outputs, comprising:

a receiver that receives training symbols via said channel outputs; and

a processor that computes characteristics of said channel based on said received training symbols and assumptions that an impulse response of said channel is substantially time-limited and that variation of said impulse response over time is continuous.

221. In a digital communication system, apparatus for communicating over a channel having at least one input and at least one output, and having a plurality of either inputs or outputs, said apparatus comprising:

means for dividing said channel into a plurality of subchannels, each subchannel corresponding to a combination of spatial direction and an input bin of a substantially orthogonalizing procedure; and

means for communicating symbols over one or more of said plurality of subchannels.

222. In a digital communication system, apparatus for preparing a sequence of symbols for transmission via a plurality of inputs of a channel, said apparatus comprising:

a plurality of parallel subchannel inputs that receive said sequence of symbols, said subchannel inputs corresponding to a plurality of subchannels, each subchannel corresponding to an input bin of a transmitter substantially orthogonalizing procedure and a channel input; and

a substantially orthogonalizing procedure processor that applies, independently for each said channel input, said transmitter substantially orthogonalizing procedure to said symbols assigned to each said channel input.

223. Apparatus for processing a sequence of symbols received via a plurality of outputs of a channel, said apparatus comprising the steps of:

a substantially orthogonalizing procedure processor that applies a receiver substantially orthogonalizing procedure to said sequence of symbols, said procedure being applied independently for each of said plurality of channel outputs, each output symbol of said receiver substantially orthogonalizing procedure corresponding to a subchannel identified by a combination of a particular output bin and a particular one of said channel outputs; and

a processor that processes symbols in said subchannels.

add A1